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Species

A preliminary mammal inventory of the southernmost Mongolian forest: discovering a mesocarnivores heaven

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ABSTRACT

In this study we present a checklist of non-volant mammal species recorded during summer-fall 2018 in the southernmost Mongolian forest located in Khangain Nuruu National Park using camera trapping, live traps, and opportunistic observations. We recorded 29 mammal species belonging to 11 families and 5 orders. Intrigungly, 7 species of mustelids are present in a ray of 15 km in addition to 5 other carnivorouse species. Among the identified species, is remarkable the record of various elusive and threatened species protected by the international law. We found a globally endangered species, a near threatened species, three species listed in the Appendix II of CITES. Our checklist can represent an important landmark for local govenments enabling to improve the wildlife management.

Keywords: Camera trapping, Khangai, live trapping, mammal checklist, Mongolian forest

1. INTRODUCTION

The study of biogeography and the conservation of biodiversity in the most remote and unexplored areas of the earth remains inadequate and afflicted by the so-called Wallacean Shortfall (Lomolino 2004). This is one of the most important challenge to which biologist must respond. More than one-fifth of all mammals in the planet are currently considered to be threatened (Schipper et al. 2008; Macdonald 2019). In Mongolia the landscape has unique characteristics as well as mammal communities. However, the socio-economic changes of recent decades have put many of these mammalian communities at risk (Clark et al. 2006), including species on the IUCN red list among rodents, ungulates and carnivores such as *Marmota sibirica*, *Camelus ferus*, *Panthera Uncia* and many other species among these groups.

The forest-steppe ecosystem is typical of northern Mongolia, it covers approximately 11% of the whole country (National Statistics Office of Mongolia, 2018), and it is characterized by hills and valleys covered by grassland with patches of silver birches and siberian larches on northern slopes that make it particularly rich in ecotones (Erdős et al. 2018). In the Khangai Nuur National Park the habitat of mountain forest steppe reaches the lowest latitude of the country, and a characteristic biodiversity is expected. In the last decades overgrazing pressure was higher in the central and western Mongolian provinces, and lowest in the eastern aimags (Gao et al. 2015). Very few studies are available among those aimed to investigate the Mongolian mammal's occurrence but mainly conducted in the desert (Augugliaro et al. 2019), desert-steppe (Murdoch et al. 2006) and steppe ecosystem (Augugliaro et al. 2020). Given the lack of information on mammals in this region characterized by a forest-steppe system, it is important to generate an updated list of mammal species (Murdoch et al. 2006; Lebedev et al. 2016). Camera trapping studies have a paramount importance to determine the presence and abundance of medium and large mammal species (Burton et al. 2015). On the other hand, small mammals can be more easily detected using live traps (Flowerdew et al. 2004). In this study we aim to draw up a preliminary mammal inventory in the northern Khangai Nuuru National Park (KNNP) in order to inform the local authorities regarding the stregths and the threats related to the mammal community.

2. MATERIALS AND METHODS

We used an integrated approach combining camera trapping and live trapping techniques following Augugliaro et al. (2019). We used camera traps to assess occurrences for medium-sized and large mammals (Rovero and Zimmermann 2016; Rovero and Marshall 2009; Rovero et al. 2013), and Sherman traps (7,6 x 8,9 x 22,9 cm) to detect small mammals (Wilson and Reeder 2005). Furthermore, we recorded the presence of the carcasses and the species sighted occasionally. We identified the conservation status following the IUCN Red List (IUCN 2019), and the Mongolian Red List of Mammals (Clark et al. 2006). Finally, we consulted the Appendices of CITES to asses the status of the detected species in relation to the international trade regulation.

Study area

Based on the local people knowledge and sighting, the KNNP is known to offer a refuge to rare and elusive mammal species, as Siberian Ibex (*Capra sibirica*), Argali (*Ovis ammon*), Siberian roe deer (*Capreolus pygargus*), Siberian Musk Deer (*Moschus moschiferus*), Wolverine (*Gulo gulo*), Grey Wolf (*Canis lupus*), Eurasian Lynx (*Lynx lynx*), Pallas's cat (*Otocolobus manul*) (BirdLife International, 2018; Batsaikhan et al., 2014).

Habitat are charachterized by Alpine vegetation above the trees line, and the southernmost forest-steppe in the country. The plants species are typical of the Mongolian forest and steppe, including trees species such as the Siberian Larch (*Larix sibirica*),

Siberian pine (*Pinus sibiraca*), and herbaceous species, such as *Euphorbia* sp., *Arthemisia* sp., and *Festuca* sp. The livestock husbandry is allowed inside the protected area if it is not harmful for the environment, according to the Mongolian law (Law of Mongolia on special protected area, Ulaanbaatar 1995). Overgrazing is also becoming an increasing threat, resulting in land degradation in the lower foothills.

The study area covered approximately 60 km^2 in 2 main zones falling in the Northern KNNP (N 46°898'; E 101°346'), Arkhangai province. In August 2018, we arrayed 45 camera traps (24 and 21 cameras respectively in the Site A and the Site B) and left the cameras unattended in the field until October 2018, to cumulate a sampling effort per camera of 50-63 days (min.-max.). To collect data on small mammals (i.e. <1 kg), we placed the Sherman live-traps in the 2 study areas. We placed 40 Sherman traps in the Site A from 20th to 22nd of August, then we moved the same traps to the Site B, from 24th to 26th of August.

We stratified the sample, setting the camera traps, between the forest patches and the Alpine rocky area up to the trees line. The camera trap models we used consisted in Reconyx, Bushnell, Browning and IR Plus. We deployed 1 camera per site, on 45 camera stations. Then we designed a grid of camera traps spaced at the minimum distance of 0.7-2 km with a view of covering the larger area possible with available camera traps.

We placed the cameras on the forced passages, animal trails and marking points, covering an altitudinal range from 2200 to 3000 m a.s.l. between valleys bottom and ridges (Fig.1). We have identified the photographed species using the Guide of Mammals of Mongolia (Batsaikhan 2010).

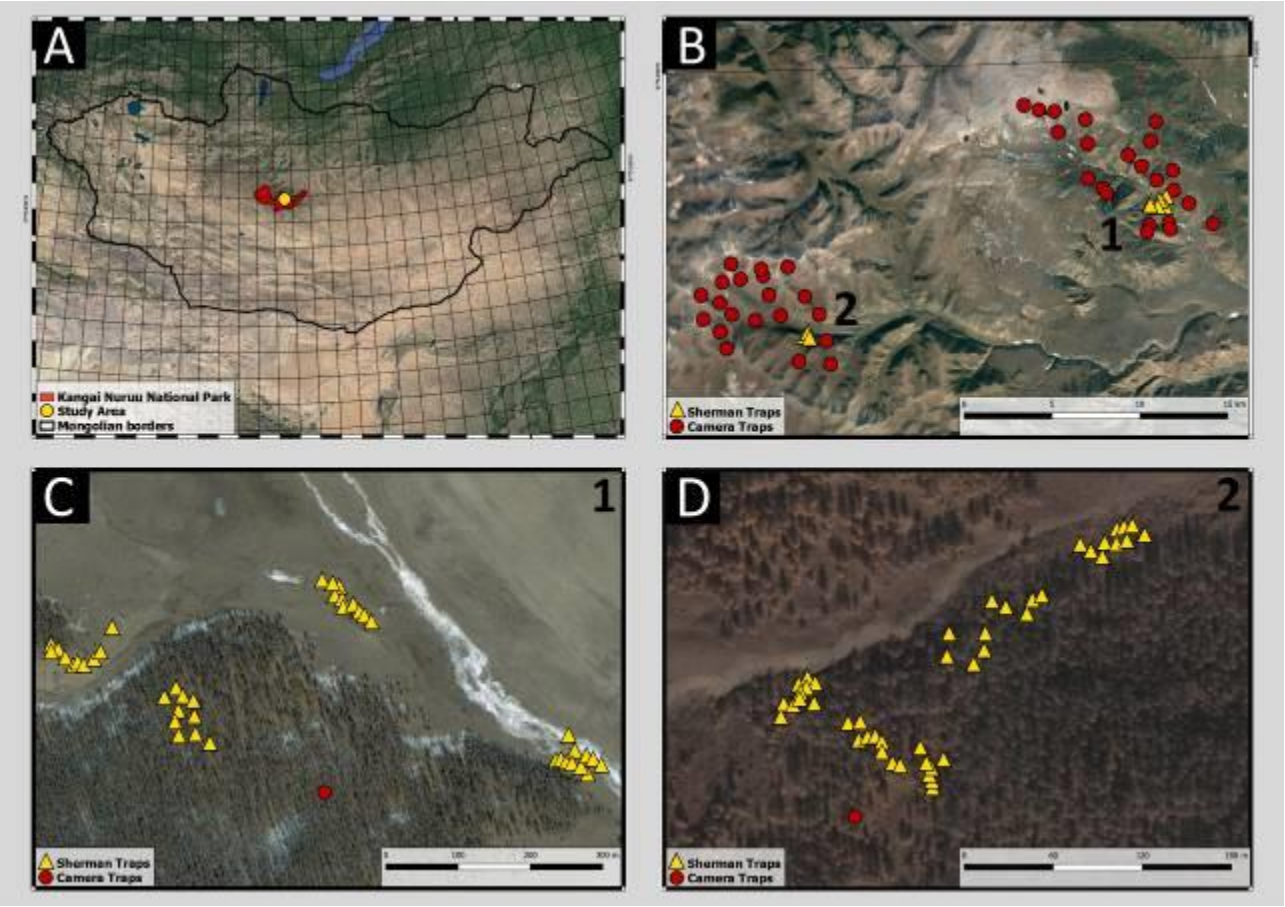

Figure 1 A) - Khangai Nuruu National Park located in the central of Mongolia; B) - The two study area with camera and Sherman trap sites; C) - Sherman sampling in the study area"1"; D) - Sherman sampling in the study area "2".

We equally distributed Sherman traps in Alpine meadow and forest steppe, we divided the traps in four group of 10. Inside the grups the traps were placed 10 m apart for two consecutives days. All traps were baited with oat or anchovies two times per day. Small mammals caught were identified and measured, then immediately released at the same place of capture.

3. RESULTS

Of the 45 camera traps placed, 35 (study area A=24, study area B=21) worked proprerly, 5 (Site A=4, Site B=1) were stolen and 5 (Site A=1, Site B=4) did not take any picture due to malfunctioning. Sampling effort of camera traps was 1560 for the Site A and 1218 for the Site B, cumulating a total effort of 2,778 nights-trap. We recorded 315 independent detections of 23 mammal species (Tab. 1, Fig. 2-3). Sampling effort of Sherman trap sampling was 80 trap days for each site. The 40 Sherman traps placed in the study site "A" captured 17 individuals of 5 different species. The 40 Sherman traps placed in the study area "B" captured 8 individuals of 4 different species (Tab. 1, Fig. 3). We identified a total of 29 mammal species belonging to 11 families (Tab. 2). The most represented family was Cricetidae with 8 species (*Alticola semicanus, Lesiopodomys gregalis, Alexandromys oeconomus, Alexandromys mongolicus, Myodes rutilus, Myodes rufocanus, Cricetulus barabensis*), followed by Mustelidae with 7 species (*Meles leucurus*, *Mustela erminea*, *Mustela sibirica*, *Gulo gulo*, *Mustela nivalis*, *Martes foina*, *Mustela eversmanii*), Sciuridae (*Marmota sibirica, Urocitellus undulates, Tamias sibiricus, Sciurus vulgaris*), Canidae (*Canis lupus*, *Vulpes corsac*, *Vulpes vulpes*), Soricidae (*Sorex caecutiens, Sorex tundrensis*), Cervidae (*Capreolus pygargus*, *Cervus canadensis*), Felidae (*Lynx lynx*, *Otocolobus manul*), Muridae (*Apodemus peninsulae*), Bovidae (*Capra sibirica*), Leporidae (*Lepus tolai*), Ochotonidae (*Ochotona alpina*). The annotated list including 29 species is reported in the Appendix 1.

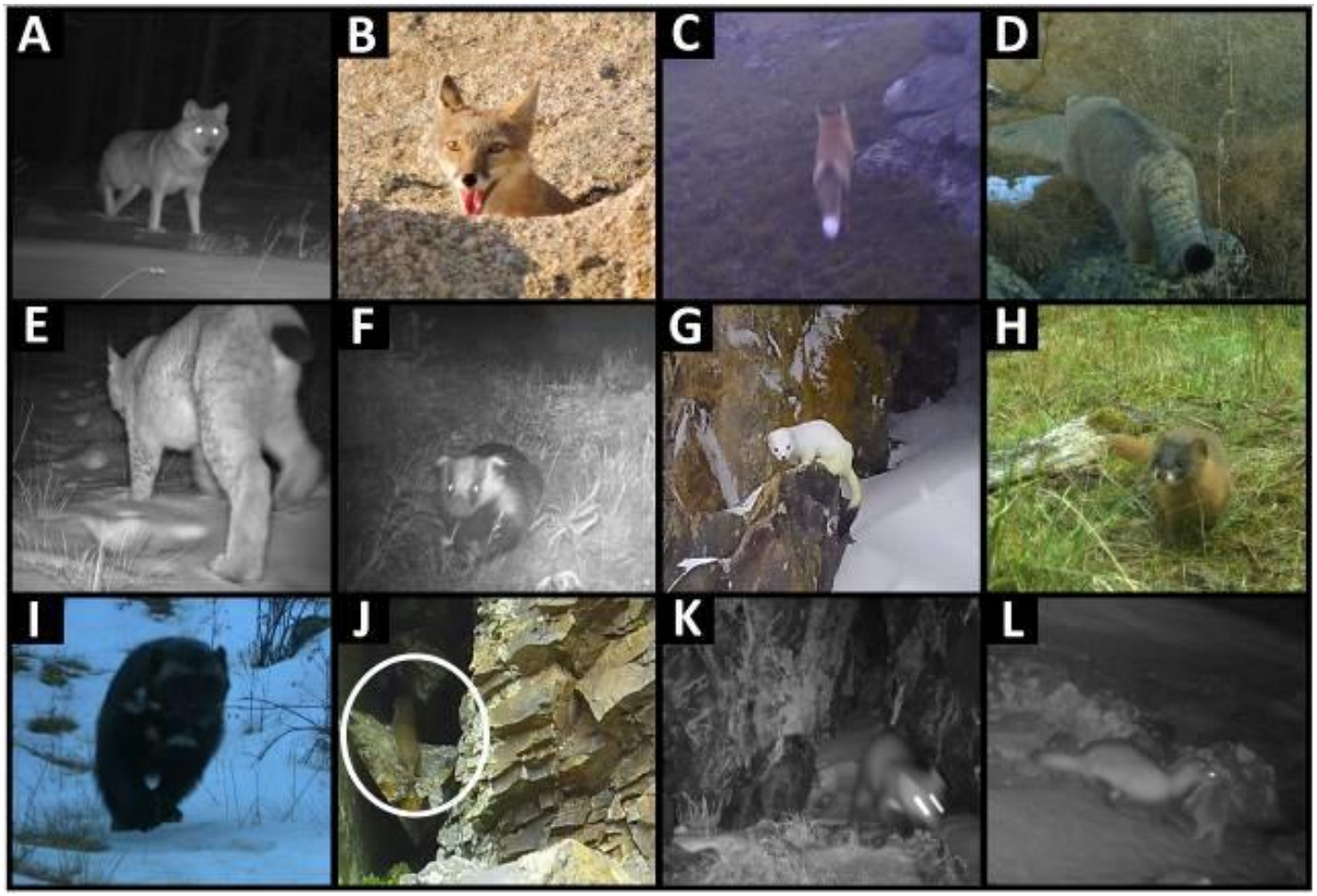

Figure 2 A)- *Canis lupus*; B)- *Vulpes corsac*; C)- *Vulpes vulpes*; D)- *Otocolobus manul*; E)- *Lynx lynx*; F)- *Meles leucurus*; G)- *Mustela erminea*; H)- *Mustela sibirica*; I)- *Gulo gulo*; J)- *Mustela nivalis*; K)- *Martes foina*; L)- *Mustela eversmanii*.

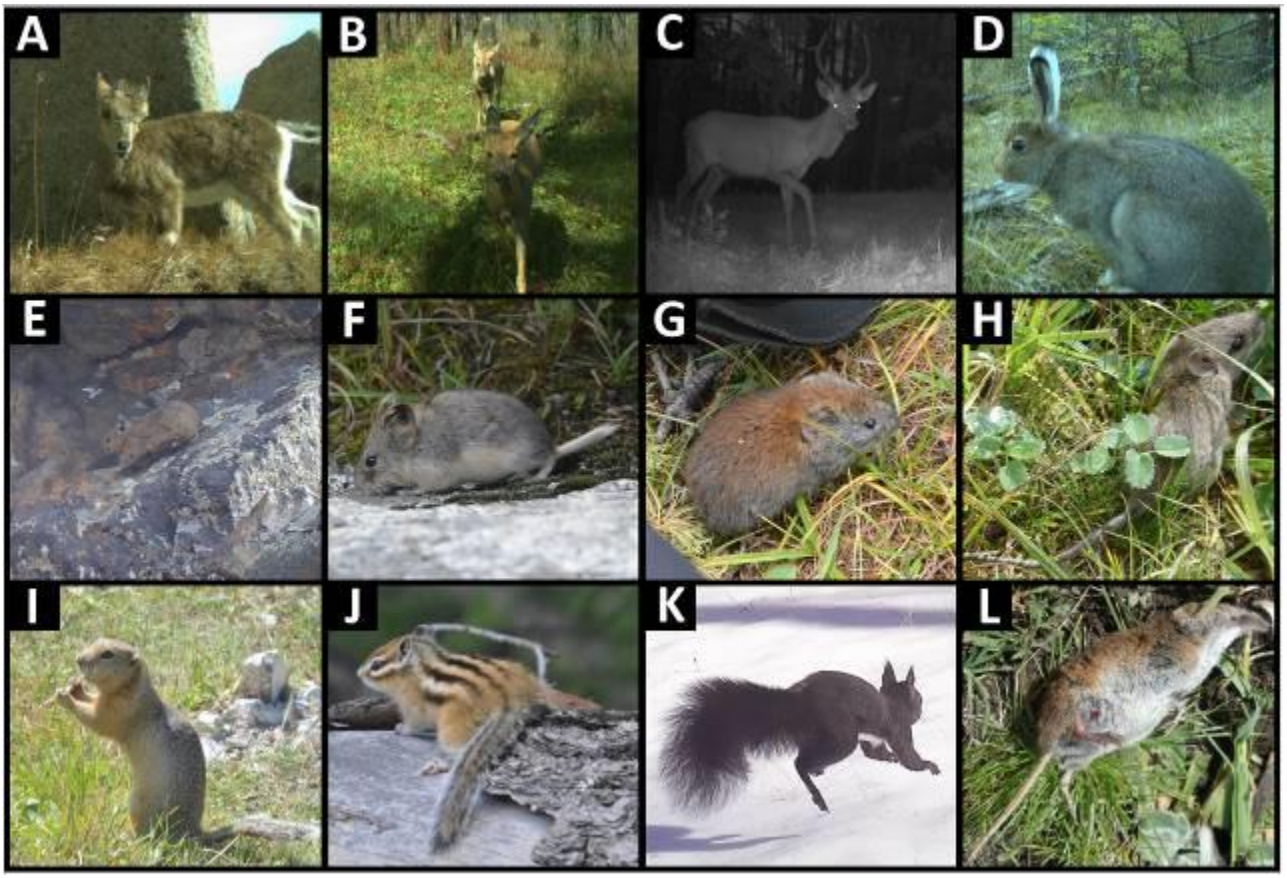

Figure 3 A)- *Capra sibirica*; B)-*Capreolus pygargus;* C)- *Cervus elaphus*; D)- *Lepus tolai*; E)- *Ochotona alpina*; F)- *Alticola semicanus;* G)- *Clethrionomys rutilus*; H)- *Apodemus peninsulae*; I)- *Urocitellus undulatus*; J)- *Tamias sibiricus*; K)- *Sciurus vulgaris*; L)- *Sprex tundrensis.*

Table 1 List of species detected in the Khangain Nuruu National Park, with regional and global conservation status based on the IUCN Red List (2019), the Mongolian Red List of Mammals (MRed List, Clark et al. 2006), and the CITES Appendices. IUCN and MRed List: Red List categories, as follows: VU = Vulnerable, LC = Least Concern, EN = Endangered, NT = Near Threatened. CITES (Convention on International Trade in Endangered Species) categories: App. I = species listed under CITES Appendix I, App. II = species listed under CITES Appendix II, NL = not listed.

Order	Family	Scientific name	Common name	Mred List	IUCN	CITES
Carnivorae	Canidae	*Canis lupus*	Grey Wolf	NT	LC	App. II
Carnivorae	Canidae	*Vulpes corsac*	Corsac Fox	NT	LC	NL
Carnivorae	Canidae	*Vulpes vulpes*	Red Fox	NT	LC	NL
Carnivorae	Felidae	*Otocolobus manul*	Pallas's Cat	NT	NT	App. II
Carnivorae	Felidae	*Lynx lynx*	Eurasian lynx	NT	LC	App. II
Carnivorae	Mustelidae	*Meles leucurus*	Asian Badger	LC	LC	NL
Carnivorae	Mustelidae	*Mustela erminea*	Ermine	LC	LC	NL
Carnivorae	Mustelidae	*Mustela sibirica*	Siberian Weasel	LC	LC	NL
Carnivorae	Mustelidae	*Gulo gulo*	Wolverine	LC	LC	NL
Carnivorae	Mustelidae	*Mustela nivalis*	Least Weasel	LC	LC	NL
Carnivorae	Mustelidae	*Martes foina*	Stone Marten	DD	LC	NL
Carnivorae	Mustelidae	*Mustela eversmanii*	Steppe Polecat	LC	LC	NL
Cetartiodactyla	Bovidae	*Capra sibirica*	Siberian Ibex	NT	LC	NL
Cetartiodactyla	Cervidae	*Capreolus pygargus*	Siberian roe deer	LC	LC	NL
Cetartiodactyla	Cervidae	*Cervus canadensis*	Wapiti	CE	LC	NL

Lagomorpha	Leporidae	*Lepus tolai*	Tolai hare	LC	LC	NL
Lagomorpha	Ochotonidae	*Ochotona alpina*	Alpine pika	LC	LC	NL
Rodentia	Cricetidae	*Alticola semicanus*	Mongolian Mountain Vole	LC	LC	NL
Rodentia	Cricetidae	*Alexandromys oeconomus*	Root Vole	LC	LC	NL
Rodentia	Cricetidae	*Myodes rufocanus*	Grey red-backed vole	LV	LC	NL
Rodentia	Cricetidae	*Clethrionomys rutilus*	Northern red-backed vole	LC	LC	NL
Rodentia	Cricetidae	*Cricetulus barabensis*	Chinese Striped Hamster	LC	LC	NL
Rodentia	Muridae	*Apodemus peninsulae*	Korean Field Mouse	LC	LC	NL
Rodentia	Sciuridae	*Marmota sibirica*	Siberian Marmot	EN	EN	NL
Rodentia	Sciuridae	*Urocitellus undulatus*	Long-Tailed Ground Squirrel	LC	LC	NL
Rodentia	Sciuridae	*Tamias sibiricus*	Siberian Chipmunk	LC	LC	NL
Rodentia	Sciuridae	*Sciurus vulgaris*	Eurasian Red Squirrel	NT	LC	NL
Eulipotyphla	Soricidae	*Sorex caecutiens*	Laxmann's shrew	LC	LC	NL
Eulipotyphla	Soricidae	*Sorex tundrensis*	Tundra shrew	DD	LC	NL

Table 2 ID = site Identification on the left, code for the single event on the right. Geographic coordinates use the WGS84 datum. Methods = record techniques used for the species: occasional sightings (OS), camera trapping (CT) and live trapping (LT).

Scientific Name	ID	Latitude(N)	Longitude(E)	Method
Canis lupus	KH01-L	46°93.943'	101°42.130'	CT
Canis lupus	KH03-L	46°93.345'	101°42.960'	CT
Canis lupus	KH07-L	46°93.263'	101°48.490'	CT
Canis lupus	KH13- L	46°92.428'	101°46.980'	CT
Canis lupus	KH23-L	46°91.520'	101°46.190'	CT
Canis lupus	KH25-L	46°91.712'	101°47.990'	CT
Canis lupus	KH33-L	46°86.378'	101°20.670'	CT
Vulpes corsac	OS-V	46°92.476'	101°49.184'	OS
Vulpes vulpes	KH04-V	46°97.644'	101°38.160'	CT
Vulpes vulpes	KH07-V	46°93.263'	101°48.490'	CT
Vulpes vulpes	KH08-V	46°92.726'	101°49.220'	CT
Vulpes vulpes	KH13-V	46°92.428'	101°46.980'	CT
Vulpes vulpes	KH14-V	46°95.090'	101°45.190'	CT
Vulpes vulpes	KH17-V	46°96.964'	101°41.84'	CT
Vulpes vulpes	KH21-V	46°91.657'	101°47.600'	CT
Vulpes vulpes	KH22-V	46°91.515'	101°46.780'	CT
Vulpes vulpes	KH23-V	46°91.520'	101°46.190'	CT
Vulpes vulpes	KH25-V	46°91.712'	101°47.990'	CT
Vulpes vulpes	KH29-V	46°87.561'	101°16.900'	CT
Vulpes vulpes	KH32-V	46°86.101'	101°14.460'	CT
Vulpes vulpes	KH33-V	46°86.378'	101°20.670'	CT
Vulpes vulpes	KH35-V	46°88.702'	101°12.940'	CT
Vulpes vulpes	KH38-V	46°89.918'	101°19.340'	CT
Vulpes vulpes	KH44-V	46°87.716'	101°18.740'	CT
Vulpes vulpes	KH46-V	46°85.169'	101°22.140'	CT
Otocolobus manul	KH04-M	46°97.644'	101°38.160'	CT
Otocolobus manul	KH05-M	46°97.810'	101°37.580'	CT
Otocolobus manul	KH26-M	46°89.415'	101°15.600'	CT
Lynx lynx	KH01-Lx	46°93.943'	101°42.130'	CT

Meles leucurus	KH01-T	46°93.943'	101°42.130'	CT
Meles leucurus	KH02-T	46°93.717'	101°42.930'	CT
Meles leucurus	KH03-T	46°93.345'	101°42.960'	CT
Mustela erminea	KH01-E	46°93.943'	101°42.130'	CT
Mustela erminea	SH06a-E	46°51.843'	101°12.419'	TR
Mustela erminea	KH22-E	46°91.515'	101°46.780'	CT
Mustela erminea	KH40-E	46°87.756'	101°14.780'	CT
Mustela erminea	KH38-E	46°89.918'	101°19.340'	CT
Mustela erminea	KH35-E	46°88.702'	101°12.940'	CT
Mustela erminea	KH26-E	46°89.415'	101°15.600'	CT
Mustela erminea	KH29-E	46°87.561'	101°16.900'	CT
Mustela sibirica	KH01-S	46°93.943'	101°42.130'	CT
Gulo gulo	KH01-G	46°93.943'	101°42.130'	CT
Gulo gulo	KH04-G	46°97.644'	101°38.160'	CT
Gulo gulo	KH39-G	46°88.481'	101°20.750'	CT
Martes foina	KH08-F	46°92.726'	101°49.220'	CT
Martes foina	KH26-F	46°89.415'	101°15.600'	CT
Mustela eversmanii	KH29-E	46°87.561'	101°16.900'	CT
Mustela eversmanii	KH39-Ev	46°88.481'	101°20.750'	CT
Mustela nivalis	KH26-N	46°89.415'	101°15.600'	CT
Capra sibirica	KH04-C	46°97.644'	101°38.160'	CT
Capra sibirica	KH05-C	46°97.810'	101°37.580'	CT
Capra sibirica	KH26-C	46°89.415'	101°15.600'	CT
Capra sibirica	KH38-C	46°89.918'	101°19.340'	CT
Capreolus pygargus	KH01-Cp	46°93.943'	101°42.130'	CT
Capreolus pygargus	KH02-Cp	46°93.717'	101°42.930'	CT
Capreolus pygargus	KH03-Cp	46°93.345'	101°42.96'	CT
Capreolus pygargus	KH09-Cp	46°91.555'	101°51.130'	CT
Capreolus pygargus	KH13-Cp	46°92.428'	101°46.980'	CT
Capreolus pygargus	KH23-Cp	46°91.520'	101°46.190'	CT
Capreolus pygargus	KH46-Cp	46°85.169'	101°22.140'	CT
Cervus canadensis	KH01-Ce	46°93.943'	101°42.130'	CT
Cervus canadensis	KH03-Ce	46°93.345'	101°42.960'	CT
Lepus tolai	KH01-Lt	46°93.943'	101°42.130'	CT
Lepus tolai	KH02-Lt	46°93.717'	101°42.930'	CT
Lepus tolai	KH03-Lt	46°93.345'	101°42.960'	CT
Lepus tolai	KH06-Lt	46°96.470'	101°39.900'	CT
Lepus tolai	KH07-Lt	46°93.263'	101°48.490'	CT
Lepus tolai	KH33-Lt	46°86.378'	101°20.670'	CT
Lepus tolai	KH46-Lt	46°85.169'	101°22.140'	CT
Ochotona alpina	KH04-P	46°97.644'	101°38.160'	CT
Ochotona alpina	KH05-P	46°97.810'	101°37.580'	CT
Ochotona alpina	KH22-P	46°91.515'	101°46.780'	CT
Ochotona alpina	KH26-P	46°89.415'	101°15.600'	CT
Ochotona alpina	KH38-P	46°89.918'	101°19.340'	CT
Ochotona alpina	KH40-P	46°87.756'	101°14.780'	CT
Myodes rufocanus	KH01-Mi	46°93.943'	101°42.130'	CT
Myodes rufocanus	OS-Mi	46°93.538'	101°46.870'	OS
Myodes rufocanus	SHCR09a-Mi	46° 51.823'	101° 12.312'	TR
Alexandromys oeconomus	SH16a-Ao	46° 51.848'	101° 12.402'	TR
Alexandromys oeconomus	KH01-Ao	46°93.943'	101°42.130'	CT

Cricetulus barabensis	SHCa1-Ba	46° 55.583'	101° 28.354'	TR
Cricetulus barabensis	SHCa2-Ba	46° 55.583'	101° 28.354'	TR
Marmota sibirica	KH33-Ma	46°86.378'	101°20.670'	CT
Urocitellus undulatus	KH06-U	46°96.470'	101°39.900'	CT
Urocitellus undulatus	KH32-U	46°86.101'	101°14.460'	CT
Urocitellus undulatus	KH36-U	46°89.918'	101°19.340'	CT
Urocitellus undulatus	KH38-U	46°89.918'	101°19.340'	CT
Urocitellus undulatus	KH39-U	46°88.481'	101°20.750'	CT
Urocitellus undulatus	KH43-U	46°88.785'	101°17.830'	CT
Urocitellus undulatus	KH46-U	46°85.169'	101°22.140'	CT
Tamias sibiricus	OS-Ta	46° 55.497'	101° 28.007'	OS
Tamias sibiricus	KH01-Ta	46°93.943'	101°42.130'	CT
Tamias sibiricus	KH21-Ta	46°91.657'	101°47.600'	CT
Sciurus vulgaris	KH01-Sv	46°93.943'	101°42.130'	CT
Sciurus vulgaris	KH03-Sv	46°93.345'	101°42.960'	CT
Sciurus vulgaris	KH05-Sv	46°97.810'	101°37.580'	CT
Sciurus vulgaris	KH07-Sv	46°93.263'	101°48.490'	CT
Sciurus vulgaris	KH09-Sv	46°91.555'	101°51.130'	CT
Sciurus vulgaris	KH21-Sv	46°91.657'	101°47.600'	CT
Sciurus vulgaris	KH22-Sv	46°91.515'	101°46.780'	CT
Sciurus vulgaris	KH23-Sv	46°91.520'	101°46.190'	CT
Sciurus vulgaris	KH33-Sv	46°86.378'	101°20.670'	CT
Sorex tundrensis	OS-So	46° 51.919'	101° 12.494'	OS
Sorex caecutiens	SHCR12-So	46° 55.449'	101° 28.359'	TR
Alticola semicanus	OS-As	46°92.622'	101°46.896'	OS
Alticola semicanus	KH26-As	46°89.415'	101°15.600'	CT
Alticola semicanus	SH007-As	46° 55.527'	101° 27.887'	TR
Alticola semicanus	SH008-As	46° 55.532'	101° 27.879'	TR
Alticola semicanus	SH0001-As	46° 55.546'	101° 27.932'	TR
Alticola semicanus	SHCR4-As	46° 55.555'	101° 28.166'	TR
Alticola semicanus	SHCR10-As	46° 55.573'	101° 28.137'	TR
Alticola semicanus	SHCR1-As	46° 55.545'	101° 28.182'	TR
Alticola semicanus	SHCR2-As	46° 55.547'	101° 28.176'	TR
Alticola semicanus	SHCR3-As	46° 55.555'	101° 28.166'	TR
Alticola semicanus	SH004-As	46° 55.523'	101° 27.904'	TR
Alticola semicanus	SH008-As	46° 55.532'	101° 27.879'	TR
Alticola semicanus	SH009-As	46° 55.530'	101° 27.870'	TR
Apodemus peninsulae	SH15-As	46° 55.487'	101° 28.009'	TR
Apodemus peninsulae	SH13-As	46° 55.505'	101° 27.992'	TR
Clethrionomys rutilus	SH19a-Ru	46° 51.825'	101° 12.314'	TR
Clethrionomys rutilus	SH21-Ru	46° 51.816'	101° 12.348'	TR
Clethrionomys rutilus	SH21a-Ru	46° 51.813'	101° 12.345'	TR
Clethrionomys rutilus	SH16-Ru	46° 51.826'	101° 12.320'	TR
Clethrionomys rutilus	SH14-Ru	46°92.407'	101°47.300'	TR
Clethrionomys rutilus	SHCR09a-Ru	46°86.462'	101°20.800'	TR

4. DISCUSSION

Results show the presence in the study areas of a diverse community of mammals with several species of conservation relevance as the Mongolian marmot, Pallas's cat, the Eurasian Lynx and the Wolverine.

The most remarkable results concern the Mustelidae family, which was represented by seven species in few sites covering a distance of 15 km. From a taxonomic and ecological point of view, seven species in a such small area is extraordinary. The

coexistence of similar species, in particular mustelids that overlap their ecological niche could be explained by selection of differently sized prey (Rosenzweig 1966; T. Dayan and Simberloff 1994; Tamar Dayan et al. 1989), behavioural differences between sexes (Zalewski 2007) interspecific aggression (Erlinge and Sandell 1988) or from combinations of these factors (Powell and King 1997; McDonald 2002) that could affect space and habitat use (St-Pierre, Ouellet, and Crête 2006). Furthermore, other 3 mesocarnivores species are present (red fox, corsac fox and Pallas's cat), that coexist and overlap the trophic niche of mustelids. Thus the 15 small mammal species observed in the study areas, that represent part of the diet of these carnivores can be considered an explanation of the high biodiversity observed. Moreover, large carnivores represented by wolverine, grey wolf and Eurasian lynx, belonging three different families have been recorded in the same camera stations, reaching a total of 12 carnivores in a such small area.

Livestock in the protected area was basically limited to sparse free ranging animals like horses and yak and few herds of goats and sheep. These domestic animals have some impact on the vegetation, but it is apparently to be sustainable. Furthermore, the livestock carcasses represent a food source for carnivores as we recorded in a video where a yak carcass were eaten by wolves and foxes (as well as shepherd dogs).

We recorded a satisfactory number of mammal species, nevertheless, every species was detected at a very low density except the red fox and the siberian roe deer, which despite were detected in few sites, they were recorded in a relatively high number of events (>50). We got evidences that illegal hunting occurs in the protected area. Our camera traps recorded a poacher on his horse with rifle, holding a carcass of the globally endangered Mongolian marmot. Furthermore, other four carcasses of wolf and 5 of Mongolian marmot had showed us by local herders living inside the protected area. We may speculate that poaching could be the greatest limitation for the wild species population growth and authorities should focus on fighting the illegal hunting inside the protected area.

5. CONCLUSION

In conclusion, we have conducted the first systematic checklist study in KNNP, which will give a considerable contribution to address the local institution to undertake the proper conservation measures in a precious mammal hotspot. We recommend future efforts to conduct additional study in a wider area, which may enrich the mammal checklist and may help to better understand the mammal community dynamics.

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Authors contribution

C.A., B.M. supervised the project, M.Z., C.A., I.E.M., N.B., G.D.D., N.C. collected the data, M.Z., C.A., I.E.M. wrote the manuscript.

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APPENDIX

ARKHANGAI ANNOTED LIST

In the Table 2 the material examined during the sampling: records, sites geolocation, species detected and detection methods. Some of the species captured by Sherman traps and camera traps are in Figures 2 and 3.

Grey Wolf (*Canis lupus* Linnaeus, 1758)

Record: Camera trap, seven sites (KH01, KH03, KH07, KH13, KH23, KH25, KH33). (Fig.2A).

Identification: The fur is mottled gray and could vary from red, brown but most commonly white and black (Wilson and Reeder 2005). The largest wild canid in Mongolia (Wilson and Mittermeier 2009), easily to identify.

Corsac Fox (*Vulpes corsac*Linnaeus, 1768)

Record: Sighting (Fig.2B).

Identification: Grayish-ocher or brown head, ears banded brown and ocher-gray, the front of the legs are light yellow. Smaller than the Red fox, with a lighter coat. Tail is generally half body length(Wilson and Mittermeier 2009).

Red Fox (*Vulpes vulpes* Linnaeus, 1758)

Record: Camera trap, seventeen different sites (KH04, KH07, KH08, KH13, KH14, KH17, KH21, KH22, KH23, KH25, KH29, KH32, KH33, KH35, KH38, KH44, KH46). (Fig.2C).

Identification: The largest fox in the genus *Vulpes,*threemain color morphs:grayish-brown, red and silver, chest and/or chest may have white part, characteristic black lower legs. The biggest fox in Mongolia(Batsaikhan 2010), and with the greater ammount of indipendent event in the Camera Trap sampling, more than ten site were occupied by Red fox (Wilson and Mittermeier 2009).

Pallas's cat (*Otocolobusmanul*Pallas, 1776)

Record: Camera trap, (KH04, KH05, KH26)(Fig.2D).

Identification: Coat silver to orange red, short-legged felid with long, dense fur, bushy tail marked with more than three rings, top of the head marked with black spots, easily to identify by it's unique and thick fur (Farhadinia et al. 2016).

The only small cat living inside the KhangainNuruu National Park(Clark et al. 2006).

Eurasian lynx (*Lynx lynx* Linnaeus, 1758)

Record: Camera trap in only one site, (KH01)(Fig.2E).

Identification: The largest in the genus *Lynx*, gray,white and brown with characteristicears's tufts of 6cm, a very short tail with a black tip at the end.

The biggest cat captured in the camera trap sampling with only one detection. Long legs and short body, easy to recognize by the short tail and the long and black hairs at the end of the ears.(Nowell and Jackson 1996).

Asian Badger (*Melesleucurus* Hodgson, 1847)

Record: Camera trap in three different sites (KH01, KH02, KH03) (Fig.2F).

Identification: The body of the Asian Badger is stocky, short legs and short tail.Tthe legs are black and the face is white, similar to the European badger, coul be diversify by this one from the shoterblach strips that running over the eye and above the ear(Batsaikhan 2010).

Ermine (*Mustela erminea*Linneaus, 1758)

Record: Camera trap and Sherman trap (KH01, SH06, KH22, KH40, KH38, KH35, KH26, KH29)(Fig.2G).

Identification: Adult Ermine males are 40-80% larger than females. Ermine has a long slender body and short limbs, during the summer the back,flanKH and outer sides of the limbs are light brown, during the winter all the brown pelage become white, exept the black tip of the tail (Aldous and Manweiler 1942).

Only one Ermine was captured by Sherman trap. Camera traps had captured it in eight sites, one easy wat to identify the ermine is the black hair at the end of the tail, unique in all the living Mustelidae of Mongolia (Wilson and Mittermeier 2009).

SiberianWeasel (*Mustela sibirica*Pallas, 1773)

Record: Camera trap (KH01). (Fig.2H).

Identification: Identification data: Camera trap.

Siberian weasel has long slender body with short limbs, the color of the pelage is dark brown during the summer and become lighter during the winter(Wilson and Mittermeier 2009).

The Siberian weasel has a black mask around the eyes and a white chin, identify by it's typical and unique red-brown coat (Batsaikhan 2010).

Wolverine (*Gulogulo* Linnaeus, 1758)

Record: Camera trap (KH01, KH04, KH39) (Fig.2I).

Identification: Wolverine is the largest terrestrial member of the Mustelidae, completely dark brown and redbrown have two distinctive yellowochre stripes that run from the top of the neck to the rump.(Holbrow 1976).

Least Weasel (*Mustela nivalis* Linnaeus, 1758)

Record: Captured by camera trap only in one site (KH26) (Fig.2J).

Identification: The Least Weasel is the smallest species in the order of Carnivora. Like the Ermine without the black tips on the tail(Heptner and Sludskii 2002). The tail is less than the 35% of the head-body length, the slender body, short limb and tail. Last Weasel change colour during the spring and autumn, in summer the upper part isbrown, and the chest is white, during the winter the coat is completely white(Batsaikhan 2010).

Stone Marten (*Martes foina*Erxleben, 1777)

Record: Camera trap. (KH08, KH26). (Fig.2K).

Identification: The Stone Marten has a long body and a bushy tail, the pelage colour ranges from brown-grey to dark brown with a pale-yellow neck. Tail and legs are darker than the restof the body(Wilson and Mittermeier 2009).

The only species of the genus Martes In Mongolia, no other similar species (Heptner and Sludskii 2002).

Steppe Polecat (*Mustela eversmanii*Lesson, 1827)

Record: By camera trap in two different sites (KH29, KH39). (Fig.2L).

Identification: The Steppe Polecat closely remember the European Polecat, the pelage ranges to yellowish-white to brown-grey. The upper part is darker with the chest, the limbs and the tail.

The only polecat captured in all the expedition, like the European polecat with lighter fur(Wilson and Mittermeier 2009).

SiberianIbex (*Capra sibirica*Pallas, 1776)

Record: (KH04, KH05, KH26, KH38). (Fig.3A).

Identification: Siberian Ibex has characteristic horns, anterior surface is flattened and back part are ridges or bosses. Horn are curve background and could be more than one meter long.

A typical beard long up to 20cm and small tiny tail(Batsaikhan 2010).

The colour of the coat is a shade brown, pale brown or chocolate.

The only wild goat of Mongolia, captured in four sites, up to 2700 meters elevation higher (Groves and Grubb 2011).

Siberian roe deer (*Capreoluspygargus* Pallas, 1771)

Record: Captured in seven camera trap's sites (KH01, KH02, KH03,KH09, KH13, KH23, KH46). (Fig.3B).

Identification: The most common wild ungulates captured by the cameras,Siberian roe deer is relative large, with a uniform pelage with absent facial mark. The winter coat is grey or brown-greywith white rump, during the summer the coat become redder (Mattioli, 2011).

Wapiti (*Cervus canadensis*Erxleben, 1777)

Record: Captured by camera trap in two sites (KH01, KH03). (Fig.3C).

Identification: Large-sized deer with a large pale rump, short tail and six antler plans. In the Siberian subspecies the large rump patch is yellow white with a tail of the same colour. The head, the legs and the neck are darker than the brown body (Batsaikhan et al. 2010).

The biggest wild ungulate of Mongolia, easy to identify, captured by cameras in two different sites (Mattioli 2011).

Tolai Hare (*Lepus tolai* Pallas, 1778)

Record: Captured in seven sites by camera trap (KH01, KH02, KH03, KH06, KH07, KH33, KH46). (Fig.3D).

Identification: The Tolai Hare have various coloration across its distribution. Dorsal coat is ocher yellow, brown or sandy grey mixed with dark and white. Ventral fur is pure white, and the tail is wholly white.The only hare present in the study area (Wilson et al. 2016).

Alpine pika (*Ochotona alpina*Pallas, 1773)

Record: Camera trap in six different sites (KH,04 KH05, KH22, KH26, KH38, KH40). (Fig.3E).

Identification: The Alpine pika is one of the largest pikas of Mongolia. The coat has a variable combination of colour; the dorsal fur is brown, reddish or ocher. The ventral fur is variable from reddish to ocherous(Batsaikhan 2010).Typical red coat, the only pikas in the study area with a such particular pelage. (Wilson et al. 2016).

Siberian Marmot (*Marmota sibirica*Radde, 1862)

Record: Sightings and Camera Trap in only one site (KH33).

Identification: The Siberian Marmot has a dorsal pelage grizzled to pale cream, the head is brown and black from the snout to the eyes. The feet are dark brown like the tail that end with a black tip. Ventral and front legs are pale cream or white (Batsaikhan 2010).

The biggest species of the Sciuridae Family, the only subspecies present in the National Park. (Wilson et al. 2016).

Mongolian Mountain Vole (*Alticolasemicanus* G.M. Allen, 1924)

Record: Sightings, Camera trap (KH26) and eleven single capture by Sherman trap (SH007, SH008, SH0001, SHCR4, SHCR10, SHCR1, SHCR2, SHCR3, SH004, SH008, SH009) the most detected species in the expedition using Sherman trap. (Fig.3F).

Identification: The Mongolian Mountain Vole has a uniform light grey coat with shaded black hair tips, with a white ventral pelage. The tail is short and white, darkened above, also the pow are white.

The only Alticola living in the KhangaiNuruu National Park, no other species could be confused with the shape and the colour of the *Alticolasemicanus* (Wilson et al. 2017).

Northern Red-backed vole (*Clethrionomysrutilus* Pallas, 1779)

Record: Captured in six different sites (SH21, SH21a, SH19a, SH16, SH14, SHCR09a). (Fig.3G).

Identification: The Northern Red-Backed vole is quite similar to the Bank Vole (*M. glareolus*), The dorsal fur is reddish-brown and ventral pelage is light grey and white, the flank are dark grey. The tail is distinctly bicolored, 1/3 of the head-body length (Batsaikhan 2010).

Unique and typical pelage, dark grey in the side part of the body and re fur in the upper part, not other species could be confused with the Northern Red-backed vole (Wilson et al. 2017).

Korean Field Mouse (*Apodemuspeninsulae* Thomas, 1907)

Record: Captured two times with Sherman traps in two different sites (SH13, SH15). (Fig.3H).

Identification: The Korean Field Mouse is a medium sized species, the dorsal fur is yellowish-brown and white and greyishwhite belly.

The only species of the genus *Apodemus* that live in the centre of Mongolia. Unique and characteristic long and dark tail(Wilson et al. 2017).

Grey red-backed vole (*Myodesrufocanus*Sundevall, 1846)

Record: Sighting and captured two times by Sherman trap (KH01, SHCR09).

Identification: The Grey red-backed vole male is generally larger than female. Upperpart and the head of the fur varies from red brown to grey; underparts are lighter, mostly grey.

Similar to the Root Vole but lighter with a shorter tail(Batsaikhan 2010).

Root Vole (*Alexandromys oeconomus* Pallas, 1776)

Record: Captured one time by camera trap (KH01) and Sherman trap (SH16a).

Identification: The Root Vole male is bigger than female. Fur colour of the upperparts and the head varies from pale brown to chocolate-brown; the underparts are brownish grey, the tail is bicolored.

Similar to the Narrow-headed Vole, darker with a red and brown coat (Wilson et al 2017).

Chinese Striped Hamster (*Cricetolusbarabensis* Pallas, 1773)

Record: Captured by Sherman trap in two different sites (SHCa1, SHCa2).

Identification: The Chinese Striped Hamster has a dorsal pelage various from grey-brown to reddish. Ventral pelage is grey, and hairs have grey bases and white tips. The tail is dark above and lighter below.

Easily to identify by the characteristic black strip that run in the middle of the back. (Wilson et al 2017).

Long-Tailed Ground Squirrel (*Urocitellusundulates* Pallas, 1778)

Record: Sightings alive and dead and captured in seven different sites (KH06, KH32, KH36, KH38, KH39, KH43, KH46). (Fig.3I).

Identification: The Long-Tailed Ground Squirrel has various colours, from yellow to russet to cher, dorsal characteristic white spots. The head is general darker with yellow cheek. The sides part of the body is reddish, the ventral pelage varies from grey-white to yellow orange.

The only ground squirrel of the study area, with a particular and distinguishable coat, most coloured between the other similar species(Wilson et al. 2016).

Siberian Chipmunk (*Tamiassibiricus*Laxmann, 1769)

Record: Sighting and captured in two different sites by camera trap (KH01, KH21). (Fig.3J).

Identification: The Siberian Chipmunk is a large species of *Tamias*, its tail is shorter than the body. The subspecies *sibiricus* is darker and less coloured than the other.

The back has five dark stripes, with a white stripe between the most lateral dark stripes. The head and the sides are ochre-yellow often light brown.

Typical and unique in all the Mongolian's Country, no other species could be confused with the Siberian Chipmunk (Wilson et al. 2016).

Eurasian Red Squirrel (*Sciurus vulgaris* Linnaeus 1758)

Record: Captured nine times in different sites (KH01, KH03, KH05, KH07, KH09, KH21, KH22, KH23, KH33). (Fig.3K).

Identification: The Eurasian Red squirrel is the only species of the genus Sciurus present in Mongolia.The colour is typically dark and variable from dark brown to lightly red, sometimes grey fur. The European Red Squirrel have characteristics ear tufts, long and pronounced in winter (Batsaikhan 2010).

Typical and unique in all the Mongolian's Country, no other species could be confused with the Eurasian Red Squirrel (Wilson et al. 2016).

Laxmann's Shrew (*Sorexcaecutiens*Laxmann, 1788)

Record: Captured by Sherman trap only one time (SHCR12).

Identification: The Lexmann's Shrew has a brown-black winter coat, with a reddish and greyish sides. Tail is sharply with two different colours in the adult. Juveniles tail has the same colour of the back.

It is not easy to identify a shrew, it was trapped only one time during the Sherman sampling, the identification it was made by the photos done during the capture (Burgin et al. 2018).

Tundra Shrew (*Sorextundrensis* Merriam, 1900)

Record: Sighting, a carcass found into the ground, it was identified directly by its skull using identification keys. (Fig.3L).

Identification: The Tundra Shrew is generally bicolored, deep brown to black. Coat are bicolored in winter and tricolored in summer (Burgin et al. 2018). Pelage is dark during the summer, dark brown to nearly black on the back, the sides are lighter brown (Batsaikhan 2010).

REFERENCE

1. Augugliaro C, Havmøller RW, Monti IE, et al. Non-volant mammal inventory of western mongolian-manchurian grassland ecoregion: a biogeographic crossroad worth preserving. Check List, 2020: 16: 287.
2. Augugliaro C, Paniccia C, Janchivlamdan C, et al. Mammal inventory in the Mongolian Gobi, with the southeasternmost documented record of the snow leopard, *Panthera uncia* (Schreber, 1775), in the country. Check List, 2019: 15 : 565–78. https://doi.org/10.15560/15.4.565.
3. Batsaikhan N. A Field Guide to the Mammals of Mongolia. In Zoological Society of London. 2010.
4. Burton AC, Neilson E, Moreira D, et al. Wildlife camera trapping: a review and recommendations for linking surveys to ecological processes. J Appl Ecol, 2015: 52: 675–85.
5. C. J. Burgin & K. He. (2018). Family Soricidae (Shrew). Pp.332-552 in: Wilson, D.E. & Mittermeier, R.A. eds. (2018). *Handbook of the Mammals of the World.*Vol. 8. Insectivores, Sloths and Colugos. Lynx Edicions, Barcelona.
6. Clark EL, Munkhbat J, Dulamtseren S, et al. Mongolian red list of mammals. Regional Red List Series 2006: Vol. 1, London. London: Zoological Society of London.
7. Dayan T, and Simberloff D. Character displacement, sexual dimorphism, and morphological variation among british and irish mustelids. Ecology, 1994: 75: 1063–73. https://doi.org/10.2307/1939430.
8. Dayan T, Simberloff D, Tchernov E, et al. Inter-and intraspecific character displacement in mustelids. Ecology, 1989: 70: 1526–39.

9. Erdős L, Ambarlı D, Anenkhonov OA, et al. The edge of two worlds: a new review and synthesis on Eurasian forest-steppes. Appl Veg Sci, 2018: 21: 345–62.
10. Erlinge S, and Sandell M. Coexistence of stoat, *Mustela erminea*, and weasel, *M. nivalis*: social dominance, scent communication, and reciprocal distribution. Oikos, 1988: 242–46.
11. Flowerdew JR, Shore RF, Poulton SMC, and Sparks TH. Live trapping to monitor small mammals in Britain. Mamm Rev, 2004: 34: 31–50.
12. Gao W, Angerer JP, Fernandez-Gimenez ME and Reid RS. Is Overgrazing a pervasive problem across Mongolia? an examination of livestock forage demand and forage availability from 2000 to 2014. in proceedings of building resilience of Mongolian rangelands. A trans-disciplinary research conference. Nutag Action and Research Institute, Ulaanbaatar, 2015 35–41.
13. IUCN. The IUCN Red List of Threatened Species. 2019. https://www.iucnredlist.org.
14. Lebedev VS, Bannikova AA, Adiya Y, et al. A revised checklist of mongolian mammal species. Erforschung Biologischer Ressourcen Der Mongolei, 2016: 13: 349–60.
15. Lomolino MV. Conservation Biogeography. Frontiers of Biogeography: New Directions in the Geography of Nature, 2004: 293.
16. Macdonald DW. Mammal conservation: old problems, new perspectives, transdisciplinarity, and the coming of age of conservation geopolitics. Annu Rev Environ Resour, 2019: 44: 61–88.
17. McDonald RA. Resource partitioning among British and Irish mustelids. J Anim Ecol, 2002: 71: 185–200. https://doi.org/10.1046/j.1365-2656.2002.00588.x.
18. Murdoch JD, Munkhzul T, Amgalanbaatar S and Reading RP. Checklist of Mammals in Ikh Nart Nature Reserve. Mongolian Journal of Biological Sciences, 2006: 4: 69–74. https://doi.org/10.22353/mjbs.2006.04.18.
19. Powell RA and King CM. Variation in body size, sexual dimorphism and age-specific survival in stoats, *Mustela erminea* (Mammalia: Carnivora), with fluctuating food supplies. Biol J Linn Soc, 1997: 62: 165–94.
20. Rosenzweig ML. Community structure in sympatric carnivora. J Mammal, 1966: 47: 602–12.
21. Rovero F and Marshall AR. Camera trapping photographic rate as an index of density in forest ungulates. J Appl Ecol, 2009: 46: 1011–17. https://doi.org/10.1111/j.1365-2664.2009.01705.x.
22. Rovero F, and Zimmermann F.. Camera trapping for wildlife research, 2016: Pelagic Publishing Ltd.
23. Rovero F, Zimmermann F, Berzi D, and Meek P. Which Camera trap type and how many do i need? A review of camera features and study designs for a range of wildlife research applications. Hystrix, 2013: 24: 148–56. https://doi.org/10.4404/hystrix-24.2-6316.
24. S. C. Schai-Braun & K. Hackländer. (2016). Family Leporidae (Hares and Rabbits). Pp. 62-150 in: Wilson, D. E. Lacher, T.E., Jr & Mittermeier, R.A. eds. (2016). *Handbook of the Mammals of the World.*Vol. 6. Lagomorphs and Rodents I. Lynx Edicions, Barcelona.
25. Schipper J, Chanson JS, Chiozza F, et al. The status of the world's land and marine mammals: diversity, threat, and knowledge. Science, 2008: 322: 225–30.
26. St-Pierre C, Ouellet JP, and Crête M. Do competitive intraguild interactions affect space and habitat use by small carnivores in a forested landscape? Ecography, 2006: 29: 487–96. https://doi.org/10.1111/j.0906-7590.2006.04395.x.
27. Wilson DE, and Reeder DAM.. Mammal species of the world: a taxonomic and geographic reference. 2005 Vol. 1. JHU Press.
28. Wilson, D. E. Lacher, T.E., Jr & Mittermeier, R.A. eds. (2016). *Handbook of the Mammals of the World.*Vol. 6. Lagomorphs and Rodents I. Lynx Edicions, Barcelona.
29. Wilson, D.E., Lacher, T.E., Jr & Mittermeier, R.A. eds. (2017) *Handbook of the Mammals of the World.*Vol. 7. Lagomorphs and Rodents II. Lynx Edicions, Barcelona.
30. Zalewski A. Does size dimorphism reduce competition between sexes? The diet of male and female *Pine martens* at local and wider geographical scales. Acta Theriologica, 2007: 52: 237–50.